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Disruption Management during Supply Chain Disruptions, Presentation

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NAVAL
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Disruption Management during Supply Chain Disruptions

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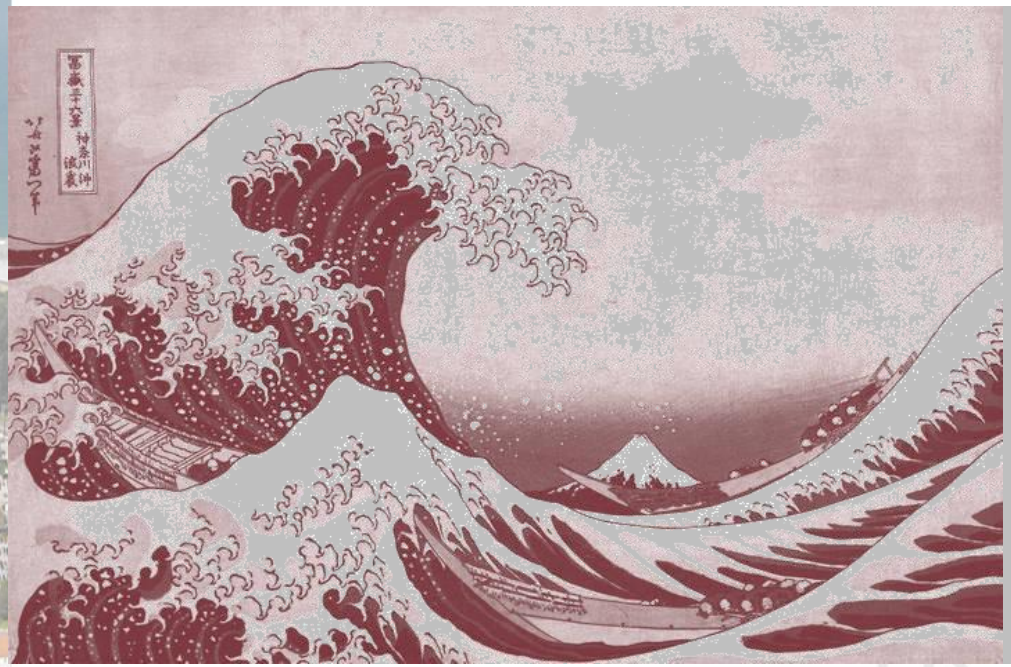
Japanese earthquake and tsunami

Outline



1. Motivation
2. Research contribution
3. Model and simulation
4. Application

Supply chain risk management

- Qualitative [1, 2]
- Quantitative
  - Production and inventory models [3]
  - Game theory [4]

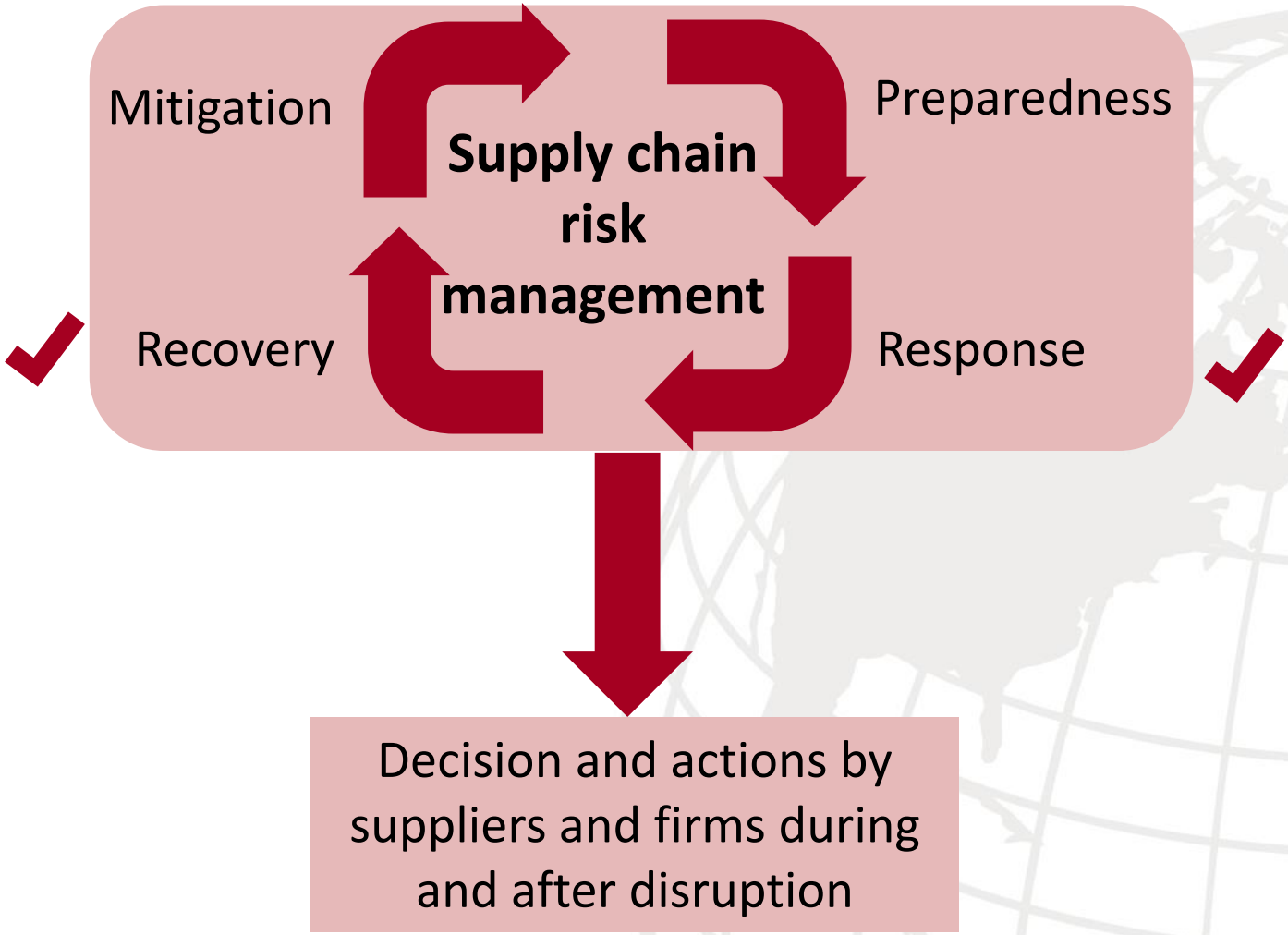
[1] Y. Sheffi, 2005. *The resilient enterprise: Overcoming vulnerability for competitive advantage*. Cambridge: The MIT Press.
[2] C. S. Tang, 2006. Robust strategies for mitigating supply chain disruptions. *International Journal of Logistics Research and Applications* 9 (1):33-45.
[3] B. Tomlin, 2006. On the value of mitigation and contingency strategies for managing supply chain disruption risks. *Management Science* 52 (5): 639-657.
[4] V. Babich, 2006. Vulnerable options in supply chains: Effects of supplier competition. *Naval Research Logistics* 53 (7):656-676.

Disruption management [1]

- Disruptions cause operation plans to deviate
- Disruption management studies optimal way to react in the midst of disruptions
  - What should be done once a disruption occurs?
  - How to minimize the impacts and return to normal production?

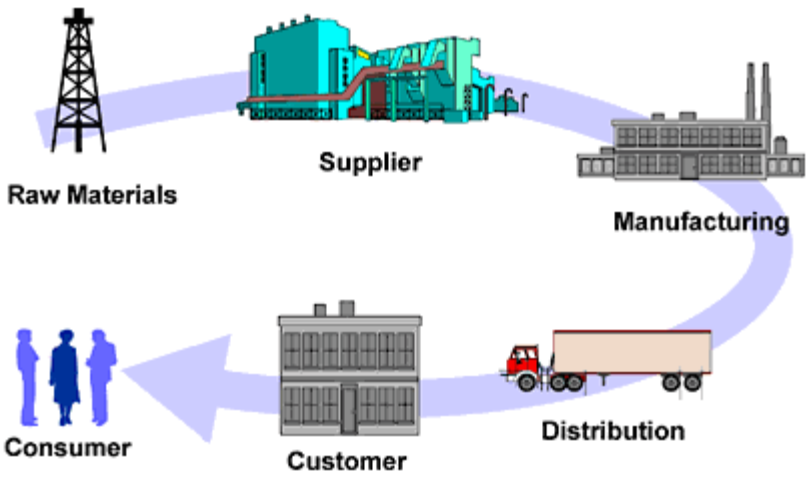
[1] G. Yu and X. Qi, 2004. *Disruption management: Framework, models and applications*. River Edge, NJ: World Scientific Publishing.

What is new with this research?



Research questions

- How can we model the supply chain where
  - Some facilities are inoperable?
  - Other firms experience a supply shortage?
- What can firms do to mitigate the impacts of inoperable facilities and supply shortages?



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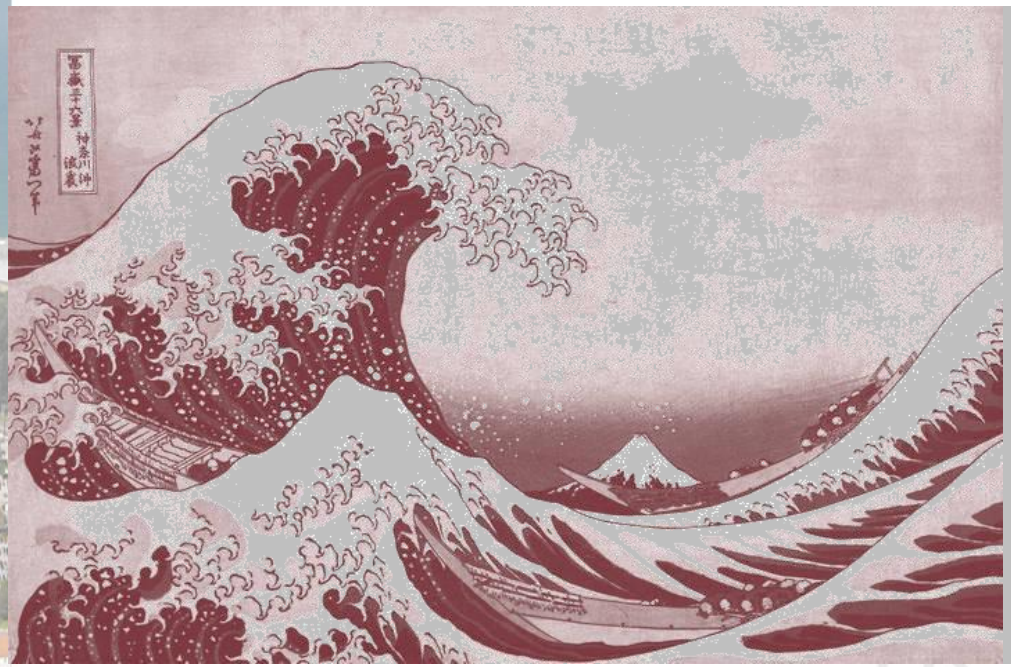

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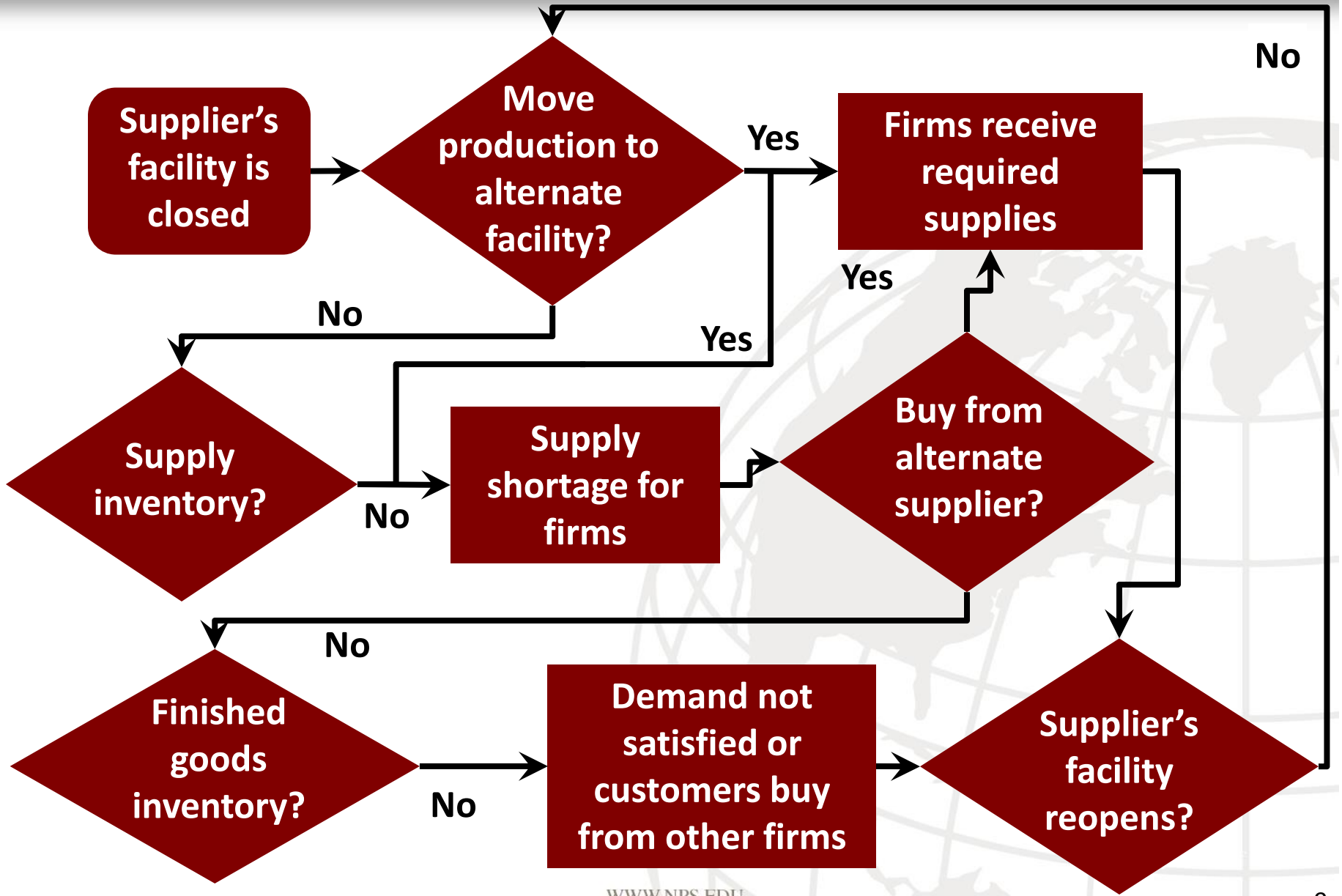
Simulation

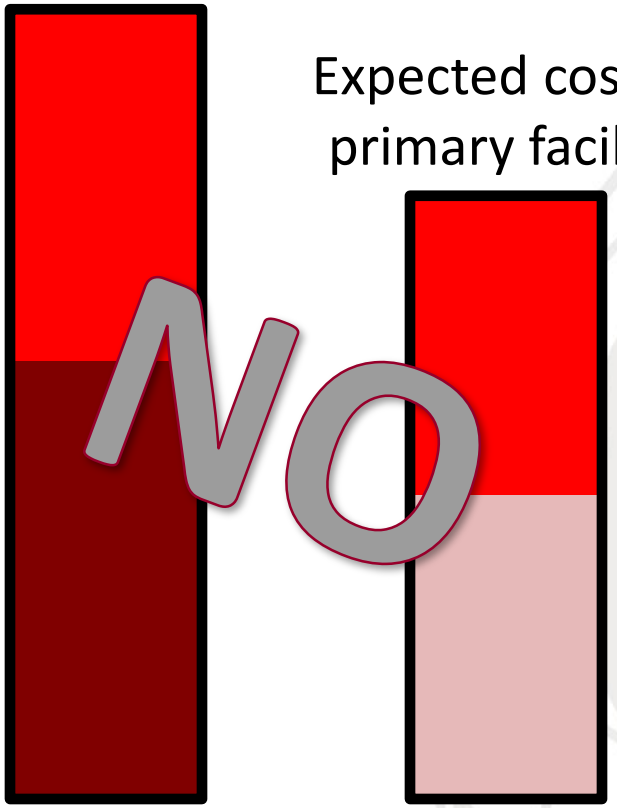

Supplier's facility is closed
Move production to alternate facility?
Yes
Firms receive required supplies
No
Yes
No
Yes
Supply inventory?
No
Supply shortage for firms
Buy from alternate supplier?
No
Finished goods inventory?
No
Demand not satisfied or customers buy from other firms
Supplier's facility reopens?

Produce at alternate facility?

Cost at alternate facility

Per-unit cost of producing at alternate facility

Fixed cost of moving production to alternate facility



Expected cost at primary facility

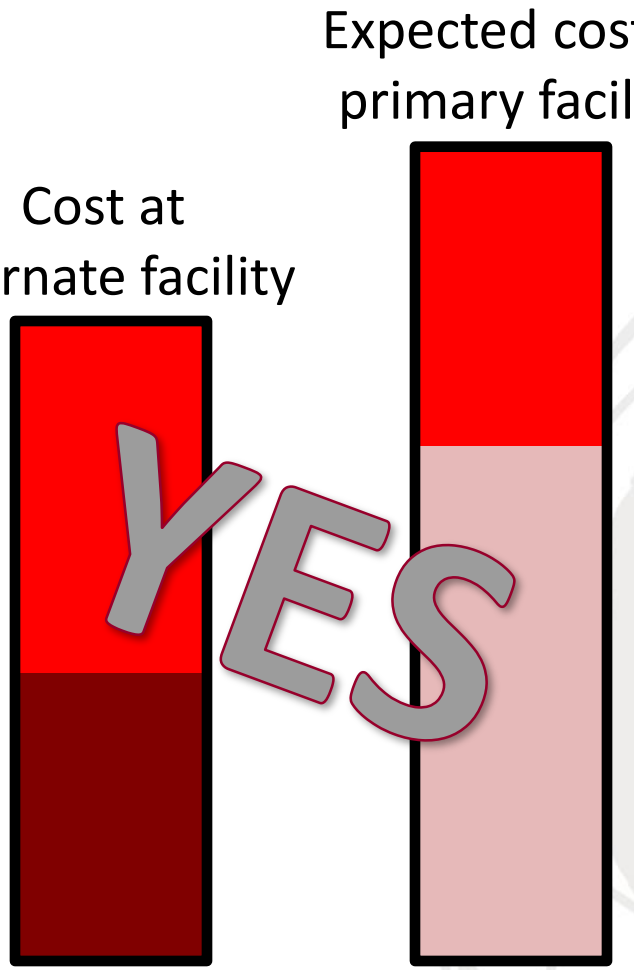
Per-unit cost of producing at primary facility

Expected lost revenue of not producing

Probability primary facility opens next period

Probability supplier's customers buy from other suppliers

Produce at alternate facility?



Per-unit cost of producing at alternate facility

Fixed cost of moving production to alternate facility

Per-unit cost of producing at primary facility

Expected lost revenue of not producing

Probability primary facility opens next period

Probability supplier's customers buy from other suppliers

Threshold parameters for supplier

If probability that primary facility will open next period is greater than $\bar{p}$, supplier will not produce at alternate facility

Per-unit revenue

$$\bar{p} = \frac{(r - c^{+})\theta}{(c^{+} - c)(1 - \theta)}$$

Probability supplier's customers buy from other suppliers

Per-unit cost of producing at alternate facility

Per-unit cost of producing at primary facility

Threshold parameters for supplier

$$\bar{p} = \frac{(r - c^+)\theta}{(c^+ - c)(1 - \theta)}$$

If fixed cost of moving production is greater than $\bar{C}$, supplier will not produce at alternate facility

Backorders

Per-period demand

Revenue

Cost of alternate facility

Cost of primary facility

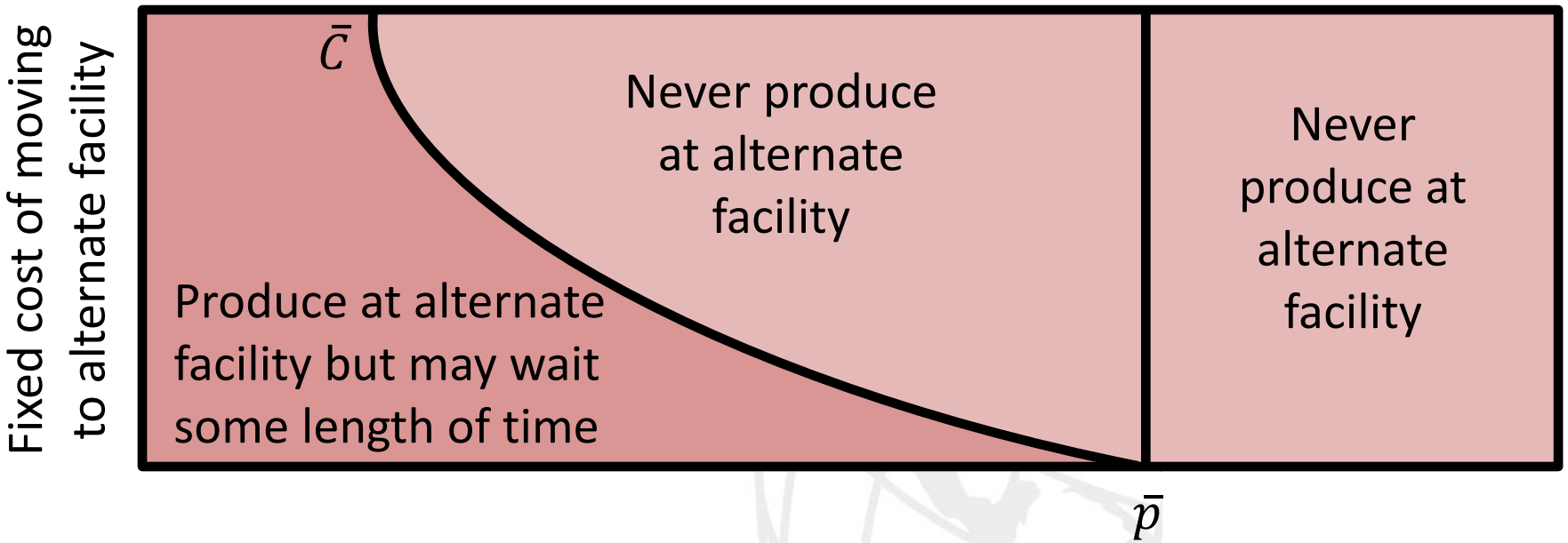
Probability of buying from other suppliers

$$\bar{C} = \frac{(pZ + z)[(r - c^+)\theta - p(c^+ - c)(1 - \theta)]}{p[1 - (1 - p)(1 - \theta)]}$$

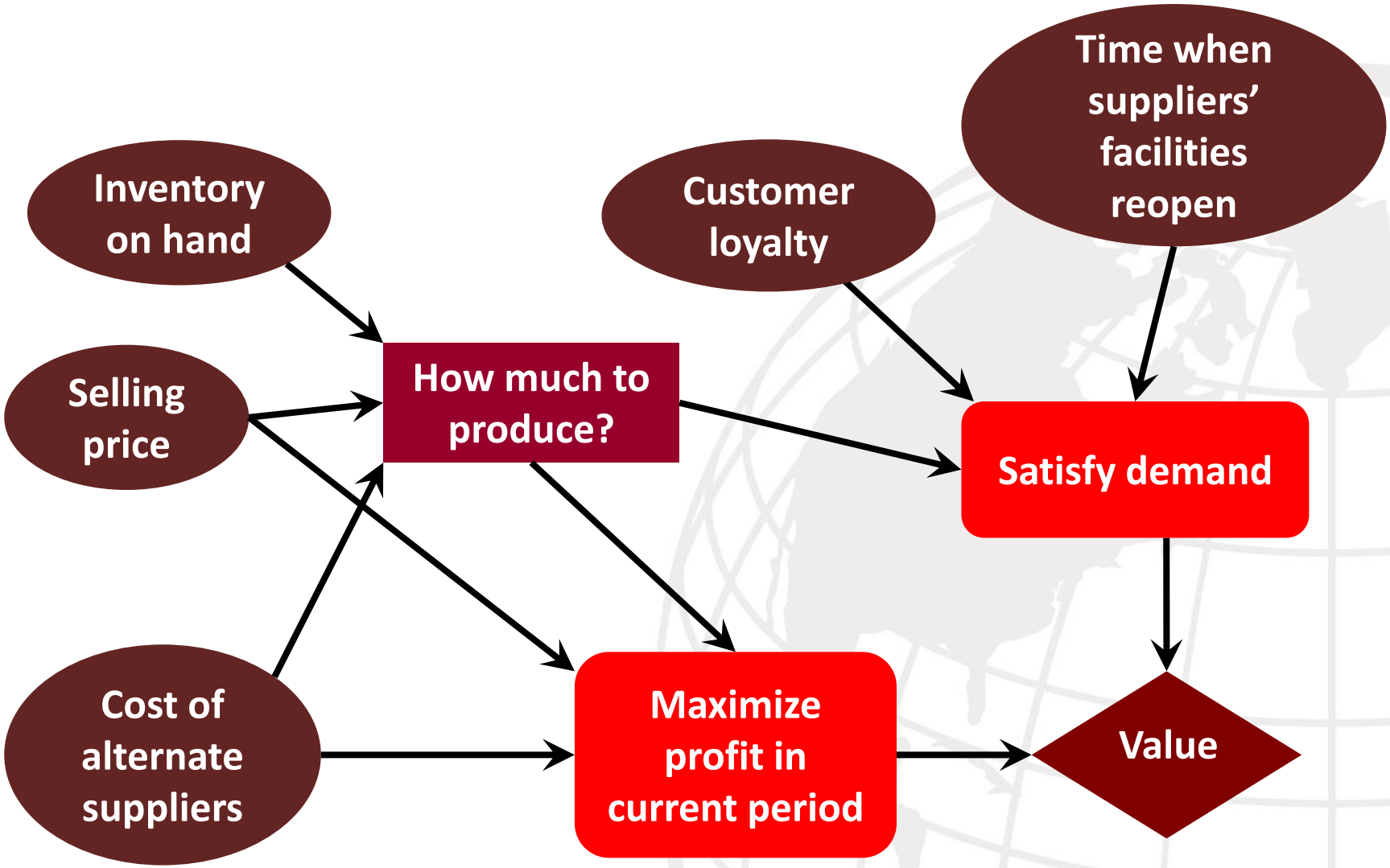
Probability primary facility opens next period

Threshold parameters for supplier

$$\bar{p} = \frac{(r - c^+)\theta}{(c^+ - c)(1 - \theta)} \qquad \bar{C} = \frac{(pZ + z)[(r - c^+)\theta - p(c^+ - c)(1 - \theta)]}{p[1 - (1 - p)(1 - \theta)]}$$



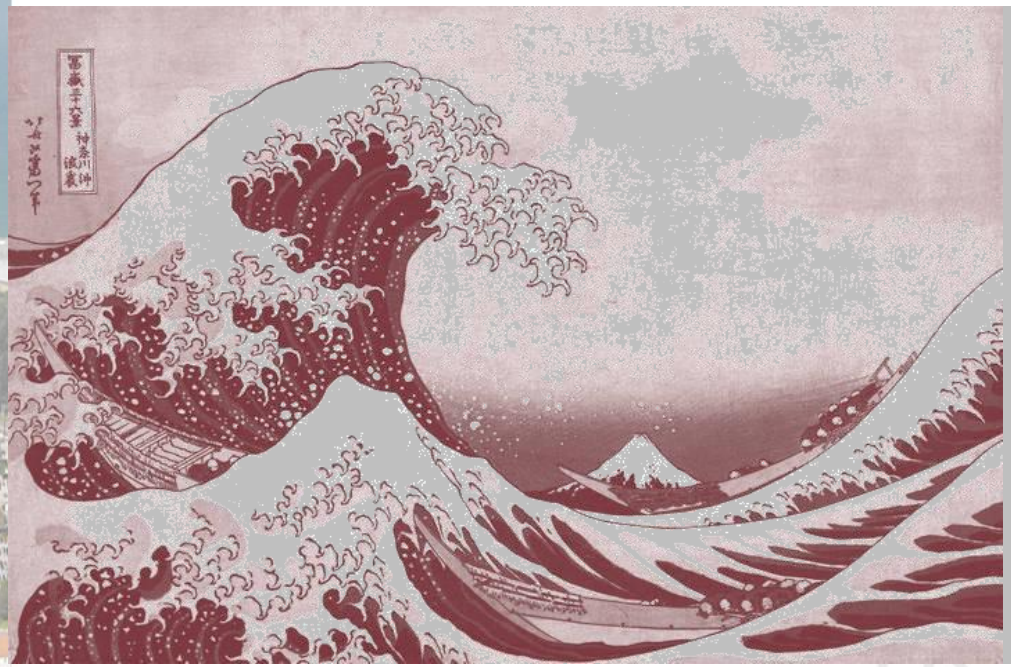
Firm's influence diagram



Modeling insights

- Incorporating business decisions in midst of supply chain disruptions
- Solving for optimal production decisions as function of model parameters
- Measuring impact of preparedness decisions on firm's ability to respond during disruption

Outline



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Supply chain disruption in auto sector

RENESAS
Everywhere you imagine.

CHRYSLER

MERCK

GM

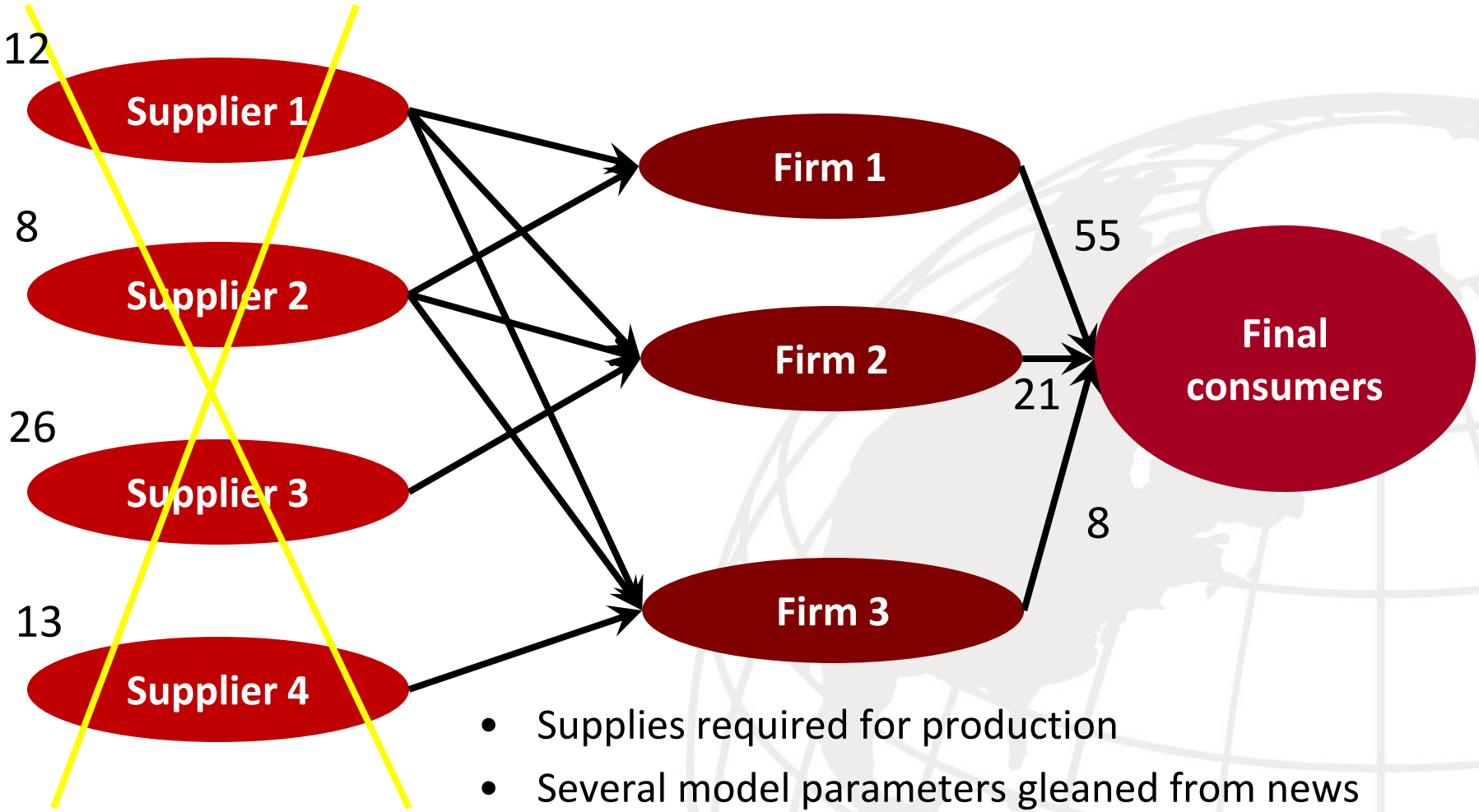
Ford

HONDA

TOYOTA

NISSAN

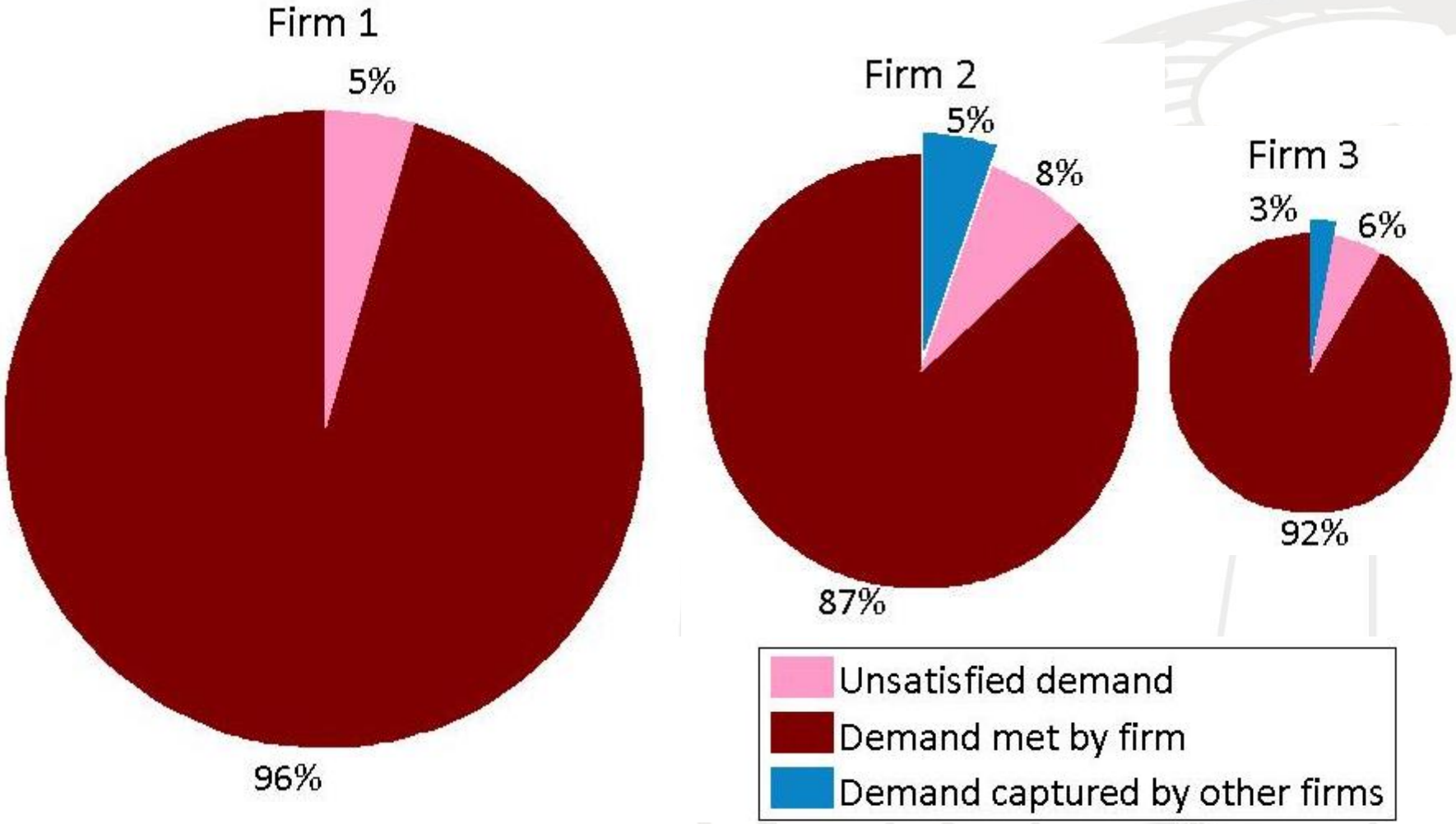
Application inspired by auto sector



- Supplies required for production
- Several model parameters gleaned from news reports
- More precise information needed for cost and revenue parameters

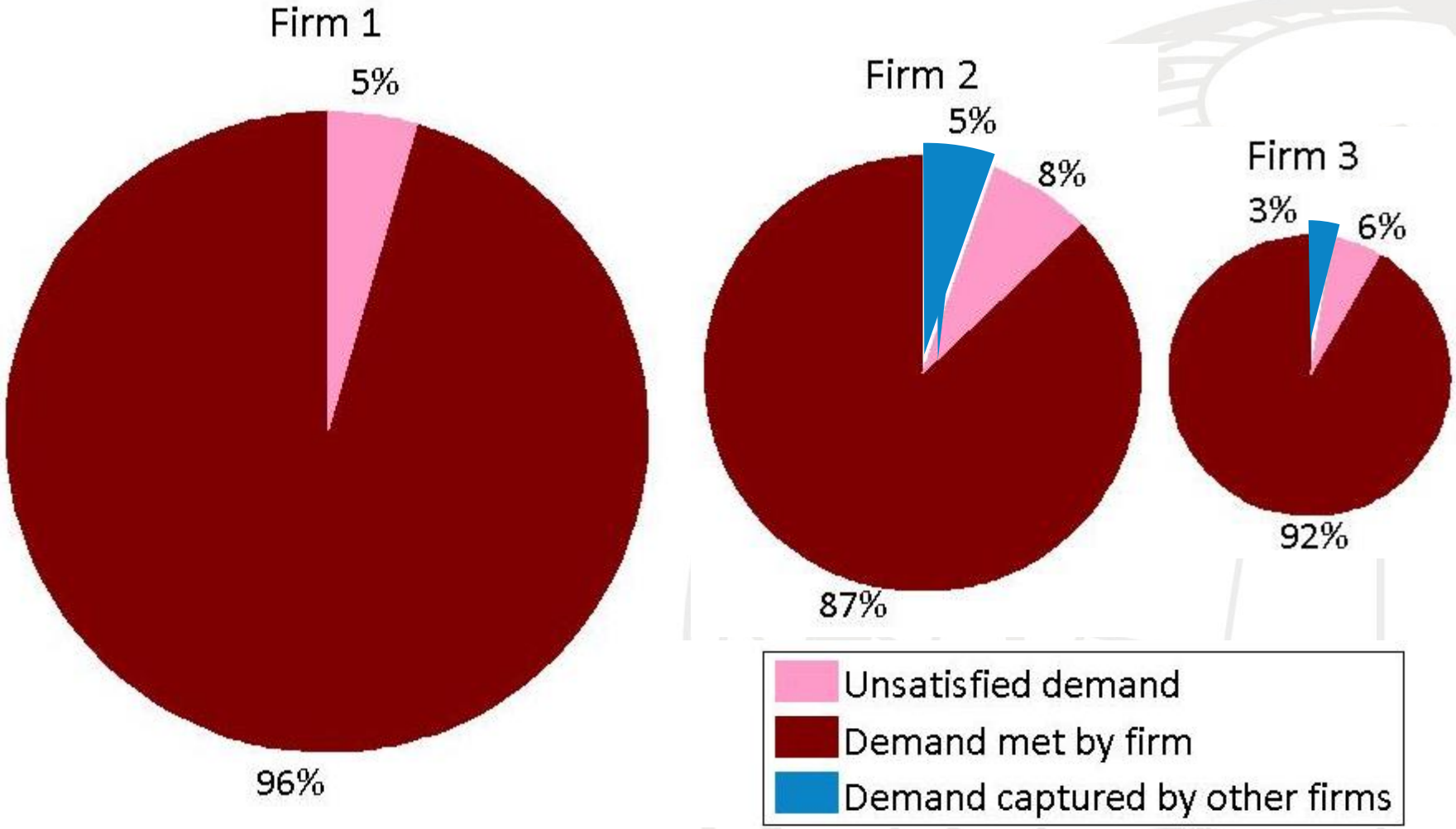
Simulation results

Average production when suppliers do not move to alternate facility



Simulation results

Average production when suppliers do not move to alternate facility



Simulation results

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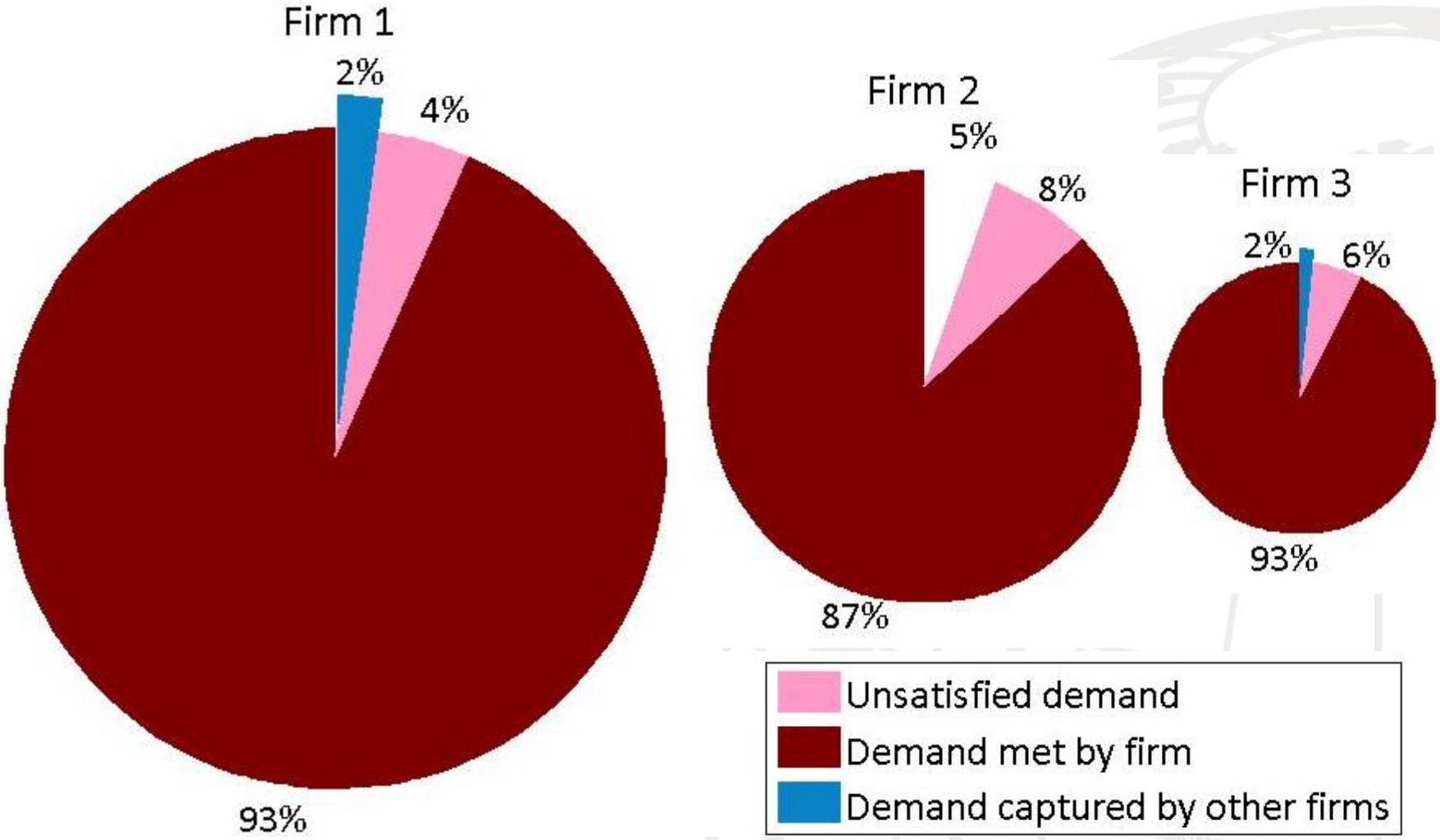
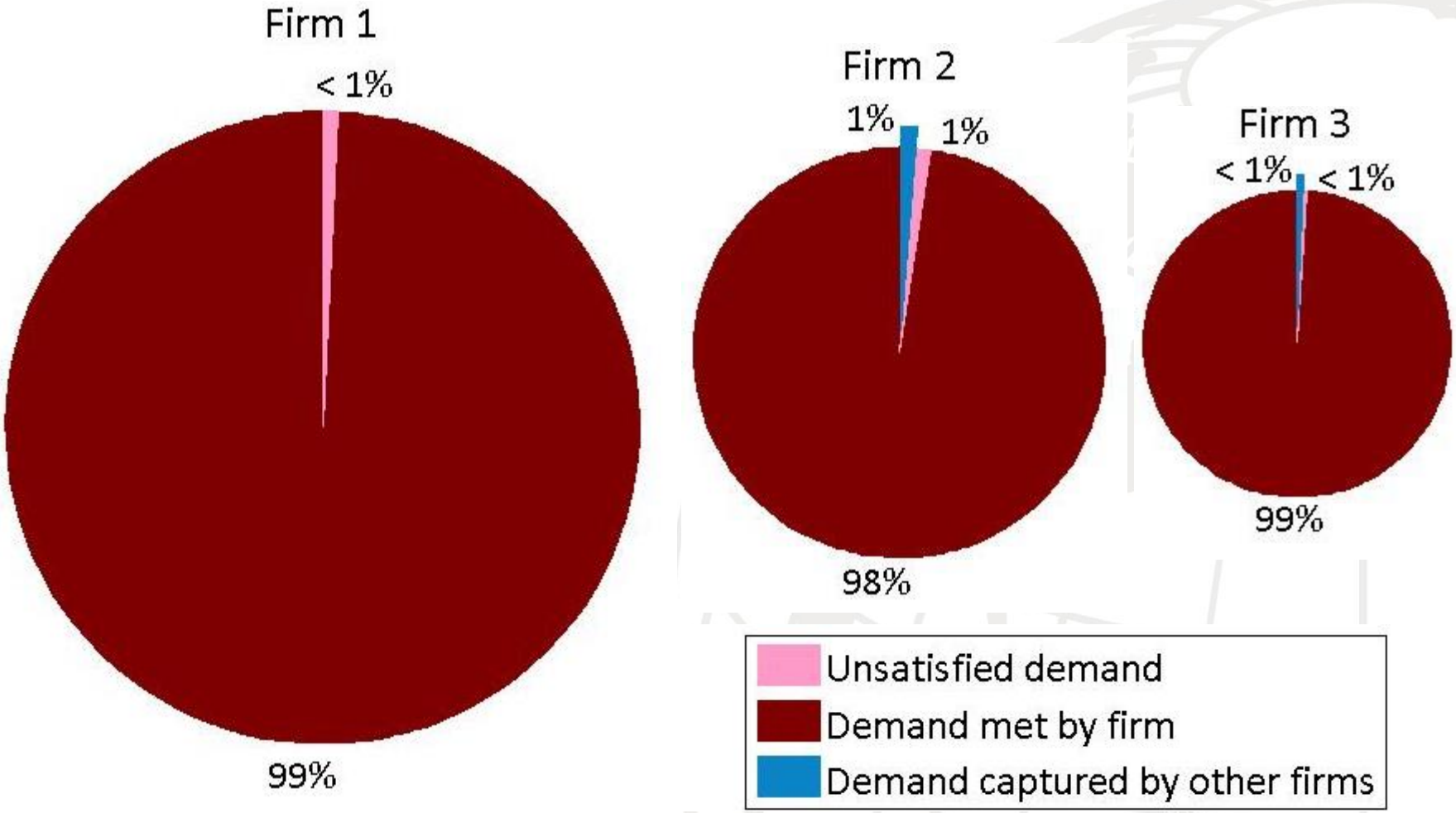


Simulation results

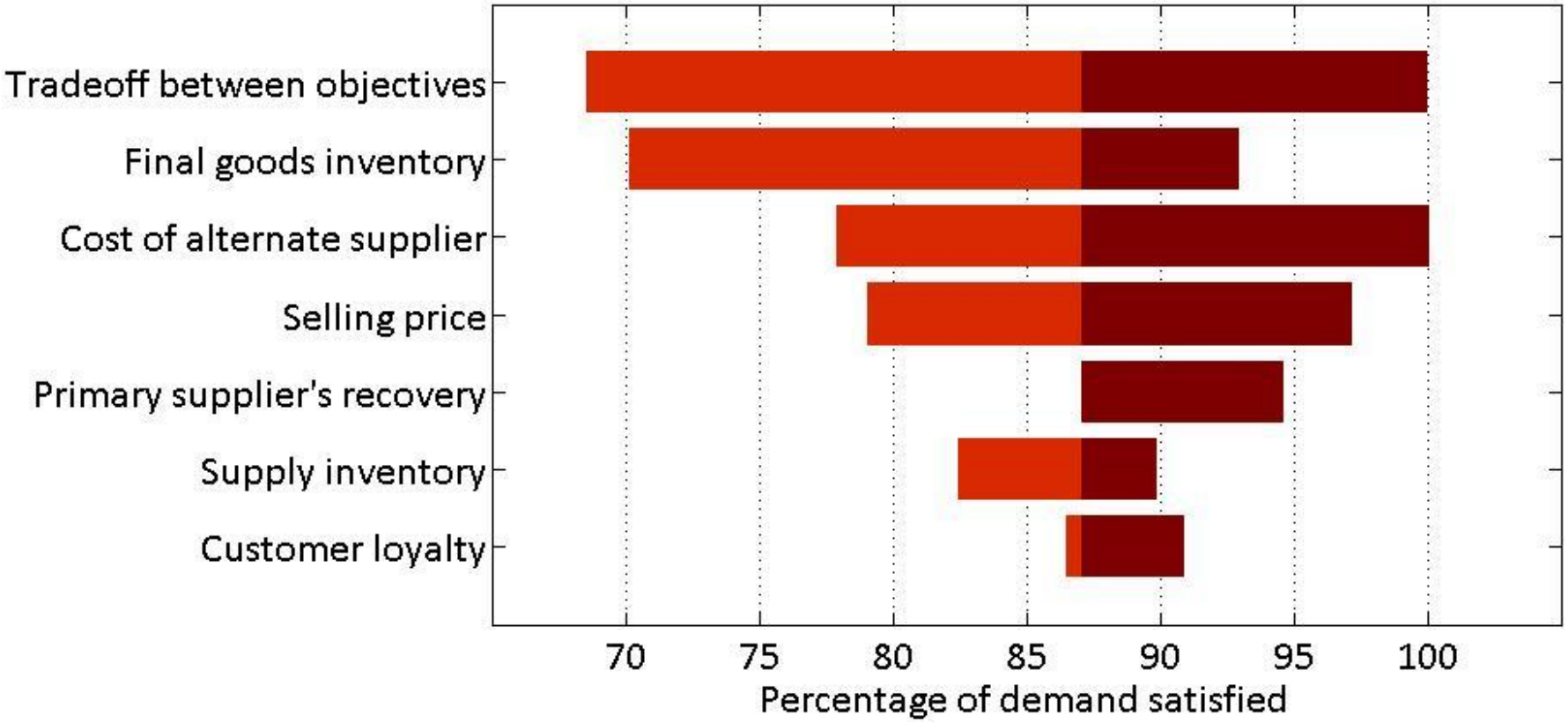
Average production when suppliers move to alternate facility



Sensitivity on parameters for Firm 2

Parameter	Low	Base	High
Tradeoff between objectives	Maximizes profit	Equally prefer both objectives	Satisfies demand
Final goods inventory	0 periods	6 periods	12 periods
Cost of alternate supplier	Primary supplier + 6	Primary supplier + 3	Equal to primary supplier
Selling price	Equal to cost	Cost + 1	Cost + 2
Primary supplier's recovery (expected time)	36 periods	26 periods	3 periods
Supply inventory	0 period	2 periods	4 periods
Customer loyalty (probability firm's customer does not buy from competitor)	0.01	0.61	0.99

Sensitivity on parameters for Firm 2



Application insights

- Illustrative example reflects actual situation
  - Toyota and Honda's share of production in North America fell from 10% to 7% each
  - Nissan's share of production in North America remained constant
  - Detroit 3 automakers increased their share of production in North America by 4%
- Application provides insights into best strategies for response and recovery
  - Buying from an alternate supplier may be a better long-term strategy than inventory
  - Costs of different strategies should be incorporated

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